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vailed that there were disease-proof varieties of the potato, but this was speedily disproved by experiment. In the discussion of the action of Bordeaux mixture the rather remarkable statement is made (p. 22) that "at present there are no clearly defined formulæ." It is difficult to understand how anything can be made more definite than the formula given for the Bordeaux mixture in Circular No. 4 of the Section of Vegetable Pathology, U. S. Department of Agriculture, issued in July, 1889. While the formula has since been modified, the directions there given were sufficiently explicit.

The second part deals with the experiments conducted by the Royal Agricultural Society in Great Britain and Ireland in 1891. These experiments were made in various places and under varied conditions, and the results were not in any way uniform. In some no benefit was reported, while in others it was very marked. The general conclusion reached, however, was that when applied at the proper time and in the proper way a decided benefit was derived from the use of Bordeaux mixture.

The third part deals with the experiments for checking the disease and the culture of the potato in foreign countries. Eleven questions were submitted to the representatives of Great Britain in Austria-Hungary, Belgium, Denmark, France, Germany, Netherlands, and the United States. These questions related to the varieties usually grown, changes of seed, methods of seeding, frequency of cropping, manner of cultivation, manures used, occurrence of disease, precautions taken against it, measures to prevent its appearance, remedies adopted, and the results of the treatment. We have here a digest of the experiments made in the countries mentioned, and it is valuable as a compilation of late information. The experiments in France, Belgium, and Holland are especially referred to, and in some cases given in full. Part 4 gives a summary of reports on potato culture in the colonies, mainly those of Australia, where, however, the disease either does not exist or does but little damage. It occurs to a greater or less extent in the Bermudas and on the Cape of Good Hope.—JOSEPH F. JAMES.

SARAUW, G. F. L.—*Rodsymbiose og Mykorrhizer særlig hos Skovtræerne*. <Bot. Tidsskrift, vol. XVIII, Copenhagen, 1893, pp. 134, pl. 2.

The present paper contains a complete account of the various theories and explanations which have been given of the "root symbiosis and the Mycorrhizæ." It contains abstracts of a large number of papers from the earliest up to the present time, while the original investigations of the author are merely alluded to. It should be pointed out that the present paper represents only the historical part of a comprehensive work entitled "*Bøgens Svamprødder*," for which the author was awarded the prize of the Royal Danish Academy of Sciences.

The various forms of parasitism are discussed as "antibiosis" and "symbiosis," terms which were proposed by Vuillemin (1889), and which

correspond to the difference between "antipathy" and "sympathy." The author defines, however, the "antibionts" to be those beings which live in a constant struggle with each other, while the "symbionts" live in peace and do not cause any injury to each other. Whether these "symbionts" are of any mutual benefit is another question. This conception of symbiosis was given by Tubeuf in 1888, who called it "harmless symbiose."

It is a marked characteristic of the antibionts that their action very soon ends the struggle, and their appearance is, therefore, rather limited. The symbionts, on the other hand, may be observed as constant companions for many years. Antibiosis and symbiosis may, when considered in this way, represent an acute and chronic parasitism.

The chapter dealing with the appearance of the "root symbiosis" comprises the "algal symbiosis," as we know it from the lichens and Hepaticæ, and the "fungal symbiosis," which causes the development of root tubercles and similar hypertrophy of roots or organs which have the same function as the proper roots, such as fronds with rhizoids like those of Hepaticæ, etc. It seems as if Dalechamp (1587) was the first to describe and figure the root tubercles of the Leguminosæ, while Malpighi (1679) also described them, and considered them as galls, caused by insects. Concerning the morphological identity of these tubercles, the Danish botanist Didrichsen (1867) explained them as being lateral roots. The anatomical structure was given by Van Tieghem (1888), who showed that they differ from normal roots by having several central cylinders within a common bark. Their first development is, however, to be traced, as in normal roots, from the pericycle of the mother root. But besides the Leguminosæ, several other plants are mentioned as having similar tubercles, both trees and herbs, from the cycads and conifers to the annual *Junci* and *Cyperus flavescentis*. The identification of most of the fungi which cause these various hypertrophies, is a very difficult task if indeed a possible one. Only a very few are known thoroughly, such as *Frankia*, *Rhizobium*, etc.

Frank was one of the earliest writers in the field and has written much. He appears to have been the first to demonstrate one phase of the question as to the biological importance of the fungal symbiosis. This author claims that certain trees, especially all the Cupuliferæ, are unable to take nourishment from the soil by themselves, but that they become nourished by means of the fungous mycelia which surround their entire root system and nurse them from their earliest stage until their death.

Gibelli, on the other hand, considers this symbiosis as a mere question of tolerance on the part of the root, and if we consider the entire literature upon this subject, it seems as if the majority of authors agree with Gibelli, that the fungus is tolerated by the root only because it does not cause it any injury.—THEO. HOLM.